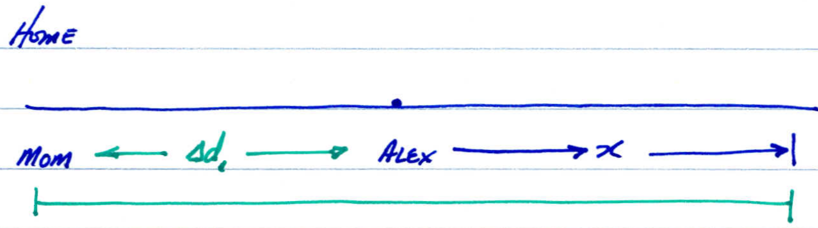
Solving Complex Motion Problems

#1 Done in class $t = 7.5\,s$ $\Delta \vec{d} = 75\,m$

#2 Done in class $t = 24$ minutes

#3



Mom has to run x + an additional distance Δd_1!
How do we determine Δd_1? Alex had been running for 6 minutes or 0.10 hours before mom got going

$\therefore \Delta d = v \Delta t$
$= 10\,(0.10)$
$= 1\,km$

Thus,

Mom	Alex
$\Delta \vec{d} = x + 1$	$\Delta \vec{d} = x$
$\Delta t = t$	$\Delta t = t$
$\vec{v} = 14\,km/h$	$\vec{v} = 10\,km/h$

uniform motion

$\Delta \vec{d} = \vec{v} \Delta t$	$\Delta \vec{d} = \vec{v} \Delta t$
$x + 1 = 14t$ ①	$x = 10t$ ②

Sub ② into ①

$10t + 1 = 14t$

$1 = 4t$

$t = 1/4\,h$ or 15 minutes $= 900\,s$

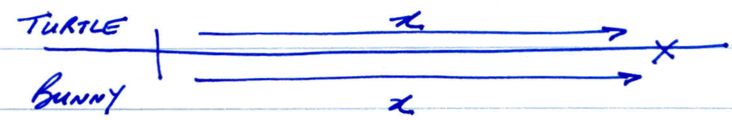
b) Substitute $t = 1/4\,h$ into ②

$x = 10\,(1/4)$
$= 2.5\,km$.

$\therefore$ Mom ran 3.5 km to catch up to him.

A Dedicated Mom!

#4



TURTLE

$\vec{v}_1 = 0\,m/s$

$\vec{a} = 0.003\,m/s^2$

$\Delta\vec{d} = x$ distance travelled is the same

$\Delta t = t$ elapsed time is the same

~~$\vec{v}_2$~~

UNIFORM $\vec{v}$

BUNNY

$\vec{v} = 25\,m/s$

$\Delta\vec{d} = x$

$\Delta t = t$

$\Delta\vec{d} = \vec{v}_1\Delta t + \frac{1}{2}\vec{a}\Delta t^2$

$x = (0.0015)t^2$ ①

$\Delta\vec{d} = \vec{v}\Delta t$

$x = 25t$ ②

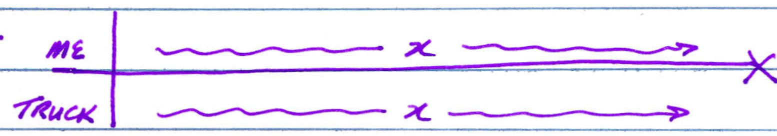
SUB ② INTO ①

$25t = (0.0015)t^2$

$t = 16666.67\,s$

$= 4.63\,h$

#5



ME

$\vec{v}_1 = 0\,m/s$

$\vec{a} = 1.8\,m/s^2$

$\Delta\vec{d} = x$

$\Delta t = t$

UNIFORM $\vec{v}$

TRUCK

$\vec{v} = 8.5\,m/s$

$\Delta\vec{d} = x$

$\Delta t = t$

$\Delta\vec{d} = \vec{v}_1\Delta t + \frac{1}{2}a\Delta t^2$

$x = \frac{1}{2}(1.8)t^2$

$x = 0.9t^2$ ①

$\Delta\vec{d} = \vec{v}\Delta t$

$x = 8.5t$ ②

Sub ② INTO ①

$8.5t = 0.9t^2$

$t = 9.44\,s.$

To find $\Delta\vec{d}$, $x = 0.9t^2$

$= 0.9(9.44)^2$

$= 80.2\,m$

TO FIND HOW FAST I WAS TRAVELLING:

$\vec{v}_1 = 0\,m/s$

$\vec{a} = 1.8\,m/s^2$

$\Delta t = 9.44\,s$

$\vec{v}_2 = ?$

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$

$= 0 + (1.8)(9.44)$

$= 17\,m/s$

#6

START

$\vec{v}_1 = 0\,m/s$ — accelerating — | $\Delta t = 10s$ — accelerating → × $\vec{v} = 1.2\,m/s$

$\vec{a} = ?$ | $\Delta\vec{d} = 10m$

|← we want to → |
find this distance

⇑

In this section the object is accelerating. To solve anything on "this side" of the problem requires us to have info on at least 3 of 5 variables. What do we know?

$\vec{v}_1 = 0\,m/s$

$\Delta\vec{d} = ?$ ← our objective

$\vec{a} =$
$\vec{v}_2 =$
$t =$
} obtaining info on two of these would be great.

$$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$$
$$0.8^2 = 0 + 2(2/50)\Delta\vec{d}$$
$$32 = 4\Delta\vec{d}$$
$$\Delta\vec{d} = 8m$$

Let's look at "the other side" of the question. What info do we know with respect to this side?

$\Delta t = 10s$
$\Delta d = 10m$
$\vec{v}_2 = 1.2\,m/s$
→ we can calculate "$\vec{a}$".

$$\Delta\vec{d} = \vec{v}_2\Delta t - \tfrac{1}{2}\vec{a}\Delta t^2$$
$$10 = 1.2(10) - \tfrac{1}{2}a(10)^2$$
$$10 = 12 - 50a$$
$$a = 2/50\ m/s^2$$

↓

We can also calculate the initial velocity at the fence post. This is the same as the final velocity of the "left side" of the problem.

$$\Delta\vec{d} = \left(\frac{\vec{v}_1 + \vec{v}_2}{2}\right)\Delta t$$
$$10 = \left(\frac{\vec{v}_1 + 1.2}{2}\right)(10)$$
$$20 = 10\vec{v}_1 + 12$$
$$\vec{v}_1 = 0.80\,m/s.$$

We now have all the info needed to calculate $\Delta\vec{d}$ from "left side".

#7

← 1200m →

TRAIN A

$\vec{v}_1 = 100\ km/h = 27.78\ m/s$

$\vec{a} = -0.9\ m/s^2$

$\vec{v}_2 = 0\ m/s$

$\Delta\vec{d} = ?$

TRAIN B

$\vec{v} = 128\ km/h = 35.56\ m/s$

$\vec{a} = -0.9\ m/s^2$

$\vec{v}_2 = 0\ m/s$

$\Delta\vec{d} = ?$

assume there is no collision and the trains come to rest. How far will each train have travelled?

Train A:

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$

$0 = 27.78^2 + 2(-0.9)\Delta\vec{d}$

$\Delta\vec{d} = 428.74\ m$

Train B:

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$

$0 = 35.56^2 + 2(-0.9)\Delta\vec{d}$

$\Delta\vec{d} = 702.51\ m.$

Combining these two distances

$\Delta d_T = 1131\ m.$

↖ The trains do not collide as the have ~69m between them.

#8

PERSON A

← 60m →

accelerates | const. $\vec{v}$.

$\vec{v}_1 = 0\ m/s$

$\vec{a} = 0.5\ m/s^2$

$\vec{v}_2 = 6\ m/s$

$\Delta\vec{d} = ?$

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta d$

$6^2 = 0^2 + 2(0.5)\Delta d$

$\Delta d = 36\ m.$

$\Delta\vec{d} = 60 - 36 = 24\ m$

$\vec{v} = 6\ m/s$

$\Delta t = ?$

$t = \Delta d / v$

$= 4s.$

$\Delta t = ?$

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$

$6 = 0 + 0.5\Delta t$

$\Delta t = 12s$

∴ TOTAL RACE TIME = 16s.

WINS BY 1s.

PERSON B

← 60m →

accelerates | const $\vec{v}$

$\vec{v}_1 = 0\ m/s$

$\vec{a} = 1.0\ m/s^2$

$\vec{v}_2 = 4\ m/s$

$\Delta\vec{d} = ?$

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$

$4^2 = 0^2 + 2(1)\Delta\vec{d}$

$\Delta\vec{d} = 8\ m$

$\Delta\vec{d} = 60 - 8 = 52\ m$

$\vec{v} = 4\ m/s$

$\Delta t = ?$

$\Delta t = \frac{\Delta d}{\vec{v}}$

$= 13s$

$\Delta t = ?$

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$

$4 = 0 + 1\Delta t$

$\Delta t = 4s$

∴ TOTAL RACE TIME = 17s!